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WHAT MINIMUM OF PRACTICAL APPLICATIONS SHOULD BE INCLUDED IN A COURSE IN ARITHMETIC.

BY C. R. DOOLEY.

THE STUDENT.

Whatever may be our definition of education it surely must in some way help the student toward a fuller and happier life—a life more abundant. The oldest thing in the world is life and therefore it is the one thing that holds our interest through all our years. Life is the application of all that we know and are and feel and whether we admit it or not any sort of formal education is the incidental thing and all classes of students make it so in spite of pedagogic pressure—and it is so. Practical applications, therefore, are reasonable, first of all because of the vital interest they afford. Any subject is most efficiently taught under those conditions which provide the maximum interest on the part of the student, and this is always obtained through some form of actual contact or association with the real things of everyday life. We all know that arithmetic, algebra, geometry, etc., are means and not ends, but we do not teach them that way.

It requires but a few practical problems to show the student the real use of a mathematical principle—to show that by a simple calculation the task becomes easier and time and effort are saved. The student gets a broader view of his work, or even of his play, sees all sides of his problem at once, the possibilities, the limitations and its relation to other problems. He feels he is working effectively. He is enthused over the great assistance his brain is able to render his hands. He adds to his interest inspiration and develops ideals of efficient service.

Formal education must accomplish two things: *First,* it must lay a foundation upon which a student may build as high as he is able without any backward step. *Second,* it must enable a student to step out into life at any stage of his schooling where either circumstances or his natural limitations call him, fully able to use his mind and body to his best ability. And we might add a third, viz., all students should leave the school room, however high they have climbed, inspired to continue their search for knowledge, but knowing that the world will always ask of them "What can you do?" and never "What do you know?"

A young man or a young woman completes the prescribed college course and we call it commencement, but the graduate does not get the idea till ten years later. The boy or girl who leaves school at the seventh grade, however, never hears anything about this commencement, except as a thing he has missed and glad of it. Neither his teacher nor his text have fitted him for a useful life, even though he far outnumbers those who get a sheepskin.

Just how far down into the grades the things of our daily life should penetrate, will probably always be a question and the answers will vary with each locality, but we are generally agreed that at present the change from school life to real life, at all stages, is too abrupt. In the subject of mechanics a square butt joint can never be as strong as a tapered splice.

THE TEACHER.

The formal teaching of any subject is a hard task for the teacher but there are at least two still more difficult. *First,* to so inspire all students that the lessons unconsciously become vital living parts of each life and not mere dead pages of a text book to be memorized. This may be a matter of proper personality which all teachers do not have. They should have it and those who do not—well, they are in the wrong job and for the sake of the children should be removed at once. Many a first-class office girl or stock clerk is struggling to make a fourth-class teacher. *Second,* to so know life and humanity as to accurately determine the capabilities of each student and then direct him along the line for which his natural qualifications best suit him.

There has been far too much of a tendency among the common and secondary schools, toward influencing any and all students to take higher educations. The result is that today there are many students struggling their way through college who ought never to have gone to college and who will never be able to make anything like efficient use of their training. Of course this training in one sense has not done them any harm and yet the time would have been more profitably spent in some other kind of training, either systematic or through experience, which would have assisted them toward a greater success, but society says "You must have a college diploma to be really respectable." I speak with some knowledge of this subject, since the company with which I am connected offers practical training each year to some two hundred graduates of technical schools, many of whom should be farmers, store clerks or policemen. And in these positions they would be successful and therefore really more respected.

It will require a new kind of teacher to recommend certain children of wealthy families to leave the formal school and entirely change their process of education and it will require a new kind of school authority to provide many kinds of training, instead of one.

The teachers of the future will be most carefully selected and trained in the same manner and according to the same standards which they, in turn, will apply to the students. They will further be required to keep in touch with practical life through regular commercial employment, at proper intervals.

W. E. & M. Company—Educational Work.

Industries are training their young men because conditions have forced them to it and not because they know better how to do it. Industries may always have to do a certain amount of detail adaptation but today they are unquestionably supplying a line of elementary instruction to their apprentices, which the public schools should do.

The educational work of the W. E. & M. Company at Pittsburgh is divided into three parts: *First, The Graduate Student Course,* open to a selected number of graduates of technical colleges. This course is two years long. Each student is required to attend class work, on company time, one or more half days per week. At present there are some 300 students on the course. *Second, The Trades Apprentice Course,* open to a selected number of boys from 16 to 21 years of age. This course is four years long. Each student is required to attend class work, on company time, four hours per week, at which he is given systematic instruction in "shop problems," "mechanical drawing" and "English." There are now some 200 students on the course. *Third, The Casino Technical Night School,* open to any man, woman or child without exception. The course varies in length, according to the ability of the student, up to 8 years. A small tuition fee is charged which covers about half the operating expense. There are now about four hundred students in attendance and 40 members of the faculty.

All of this is costing a great deal of money not as an experiment but as an investment which is yielding good results.

SHOP PROBLEMS AS TAUGHT IN THE TRADES APPRENTICE COURSE AND IN THE CASINO SCHOOL.

As a rule boys come to us thoroughly disgusted with school. They want to work. We give them work, but they also have to go to school 4 hours each week and they soon get to like it—some so much so that they return to public school with a new vision and appreciation.

No text book is used. The problems are all made up by an instructor in charge of the work. A few characteristics of these problems are notable. *First,* the language and names of things used in stating the problems are those met with in daily life about the factory. *Second,* there are no abstract problems, such as $\frac{3 \times 8}{1/4}$. Each problem is a definite practical statement closely related to daily experience. *Third,* no hard and fast divisions of "arithmetic" such as "decimals," "fractions," etc., are held up before the boys. *Fourth,* no formal rules or methods are set down to be committed. *Fifth,* a problem is more than a mere problem—it is a statement of real conditions and often more data is given than is needed, requiring proper selection and statements. While little in advance of the arithmetic is taught yet the formal word "arithmetic" is not used. The boys are graded into several classes according to the classification of the ordinary arithmetic in a very general way, but at all times they are studying "shop problems" and not "decimals" or "percentage." The problems are to be solved by analysis and the applications of general principles, without regard to whether these principles belong to "Proportion" or to "Mensuration." Each principle is explained only after a need for it has arisen.

We have found boys whose previous schooling had been so formal that they could not do long division without placing the dividend, divisor and quotient in certain definite relative places. A student should so comprehend such an operation that he could put the dividend on the black-board; the divisor on a scratch pad and write his answer on the floor; and he may do all this in a neat and orderly manner. Neatness and order do not mean conformity to one definite form laid down by the law.

Rules are not given with the command, "Learn these for they will be useful later on." But the boys are put up against problems of real shop experience and then by the guidance of the instructor, the proper method is explained and the student assisted in formulating his own expression of such rules as are necessary. I gave this problem to a class of fifteen apprentices: $\frac{3 \times 8}{1/3}$; and they solved it readily. Half an hour later the following was given to the same class: "How many bolts each 4" long can be made from three brass rods ½ inch in diameter and 8 feet long?" Not one saw the similarity between this problem and the previous one. Some asked what to do with the ½ inch diameter and one thought bolts were made of iron, and the brass in this problem bothered him. After a little suggestive discussion, about half the class fully comprehended the problem and its solution.

Another example will illustrate the practical application of fundamental principles. This problem was given one of the *advanced* classes and was readily comprehended and solved. "A casting weighing 4,000 lbs. is to be raised by means of a crow-bar. The distance from the point of the bar under the casting to the pry-block is four inches; the distance from the pry-block to the point where the bar would be grasped is four feet." The question asked was not how many pounds weight will balance the load, but how many men will be required to raise the casting.

Immediately some one asked how much a man weighs and the reply was, "Use your judgment, would you send one man or ten to do the job?"

Then the problem was carried further. "How high will the casting be raised?" They soon decided that it could be raised about one inch. Then they were asked, "How many men will be required to raise it ten feet, and the answers came thick and fast all the way up to 120 times as many men. By-and-by one boy said, "two men—just keep blocking up the casting," and another said, "then you'll need another man, one to fix the blocks"; and so on leading the boys to think out rational solutions to everyday problems by the application of the fundamentals of arithmetic. In the case just cited they were dealing with proportion but they did not know it as a formal, dead and difficult part of the arithmetic to get through with on examination day.

The majority of our boys have left the public school at the seventh grade and have been out of school from one to two years. Out of 100 who took a classification examination, 50 could not add decimals or complex fractions and but 25 could *at all* handle problems in simple percentage. The great majority had absolutely no conception of the physical meaning of problems in areas and volumes. I have asked many new boys to find the area of the top of my desk 4½ feet by 5½ feet, and received the answer $4\frac{1}{2} + 5\frac{1}{2} = 10$ or "I have forgotten the rule."

These cases are not exceptional; they represent at least 50 per cent. of the boys who come to us. Nor are these boys stupid and dull. On the whole they are wide awake and of good appearance. They take readily to leading suggestions and are making wonderful progress in their application of fundamental principles to the practical problems of their daily lives. Interest runs high, for they find their shop work is easier and more intelligible.

As far as possible the boys are never required to take anything for granted because its derivation is based on "higher mathematics." *For example:* The value of pi is proved quite to the satisfaction of all by providing a dozen or more discs of different diameters. Each boy measures the diameter and circumferences of these discs and works out the ratio in enough cases to satisfy him. The specific weight of different metals is also worked out by measuring and weighing numerous samples in the class room. This creates interest and fixes values in the memory. The apprentice knows that a cubic foot of cast iron weighs 450 pounds because he has calculated it a dozen times with as many different pieces and has checked his results with the scales.

We give a boy a pulley, a piece of rope, a weight and a spring balance and tell him to find out all he can. What force is required to lift the weight? Does this force change with pulleys of different diameters? Does it change with ropes of different sizes? Where have you seen a similar use of a pulley in the shop? Can this apparatus be arranged so that a force of 5 pounds will lift a weight of 10 pounds?

After he is through with his test he has the laws of the single pulley fixed in his memory in his own language. This is carried on through hundreds of combinations with pulleys, levers, gear wheels, weights and measures, screws, force combinations, etc. All this is mechanics and is interwoven with arithmetic, algebra, geometry and trigonometry, but these are absolutely incidental to the physical appreciation and solution.

A few months ago we established a series of talks by the instructors on shop topics such as, "Machine Tool Parts," "Small Tools," "Standard Bolts, Nuts and Washers," "Castings," "Brass," "Iron," "Steel," etc. At the end of a four months' term, an examination was held with the result that those talks which had been illustrated by objects had been universally remembered and the others largely forgotten.

Practical Problems for the Public School.

Select the things in which each class of children is interested and build the problems about them.

An associate of mine recently told me that his boy of ten was much distressed because he was unable to teach the housemaid how to add. She could not seem to understand his explanation that: "Addition was the process of taking . . ., etc." When asked if she brought home the correct change with the grocery order, he replied, "Oh yes, she can add it all right, but she can't understand the rule."

Grocery store calculations are full of additions, subtraction, multiplication, division, percentage and fractions.

If a 4-lb. roast cost 25c. a lb., and afterward the bone weighed 12 oz., what did the actual meat cost? What is the percentage of waste?

What is the diameter of your bicycle wheel? How many revolutions does it make to the mile? How many revolutions of the pedals to the mile? Is there any ratio between the proper of teeth on the two sprockets and the revolutions per mile of each?

The small boys' wagon has wheels of 8 and 10 inches diameter. How many revolutions does each of the four wheels make if the wagon is pulled once around a circle of 10 feet diameter?

"What are the percentages of each member of your baseball team?"

You deposit $1.00 per month in a savings bank, paying 4 per cent. per year, interest being credited to your account every six months. How does your account stand at the end of 17 months?

Material for a skirt costs 75c. a yard. Seven yards (or 2½ yds. nowadays) are required; thread and trimming cost 50c. What is the cost of the skirt? How long would it take you to make it? Can you afford to learn to make such garments if the ready-made price is $15.00; and what could you save per year by so doing?

Determine the height of the school building without actually measuring it.

Find the dimensions of each board used to make a box which will just contain a can of carbon oil 41″ high × 17″ diameter. If it weighs 100 lbs. and is to be shipped from Chicago to St. Louis, which will be the cheaper, by express or freight, and how much? Which will be the quicker and how much?

How many days till the Fourth of July, and each day what percentage is the time reduced from the preceding day? Show the result by a curve.

Each student should be required to collect his own data from his own experience and investigations. To carry out such a scheme, we should have 100,000 problems, classified as to subject matter (not as percentage, proportion, etc.), under a hundred different heads and then each group arranged according to degree of difficulty. Then, day by day, each student should get that kind of problems that will catch his greatest interest. This means individual instruction, but we've been too long already with aiming at the average of a class of 40 boys and girls, no two of whom are anywhere near alike in any way.

Our present system is perhaps not bad for the average child and those below, but it is sure death to the natural powers of the bright ones.

Conclusions.

Practical applications in a course in arithmetic will do the following:

1. Create the greatest interest.
2. Lay the best foundation for future mathematics.
3. Give the maximum utility at any time it becomes necessary for a student to leave school.
4. Provide a sure means of sizing up students and directing them toward that life work for which they are best fitted.
5. Inspire the student with ideals of labor and citizenship.
6. Encourage a spirit of eternal inquiry, investigation and observation.
7. Provide a certain knowledge of the things and of the people of the world.
8. Give some appreciation of wholesome economies and a sense of proper relationships and proportions.

The minimum of practical application which should be included in a course in arithmetic is not far from 100 per cent., and the application should precede the principle.

Westinghouse Electric and Mfg. Co.,
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